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Study of $Cu_2CdGeSe_4$ monograin powders synthesized by molten salt method for photovoltaic applications

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Abstract

$Cu_2CdGeSe_4$ monograin powders were synthesized by molten salt method for photovoltaic applications. The effects of salt material (CdI_2 and KI), synthesis temperature and time on the structural, morphological, compositional and optoelectronic properties were investigated. Phase analysis by Raman spectroscopy and X-ray diffraction methods showed that the $Cu_2CdGeSe_4$ powder crystals synthesized at 500 °C had tetragonal structure and those synthesized at 600 °C and 700 °C had orthorhombic structure. The band gap values determined from external quantum efficiency measurements were 1.27 eV for orthorhombic $Cu_2CdGeSe_4$ and 1.14 eV for tetragonal $Cu_2CdGeSe_4$ powder crystals. The monograin layer solar cell on the base of orthorhombic $Cu_2CdGeSe_4$ powder showed the best conversion efficiency of 4.21% (active area), with an open-circuit voltage of 0.46 V, a short-circuit current density of 23.3 mA/cm^2 and fill factor of 39%.

Keywords: molten salt synthesis-growth; Crystal structure; Solar cells; Copper cadmium germanium selenide

1. Introduction

There is a large group of ternary and quaternary copper chalcogenide compounds that have attracted considerable attention due to their suitable properties for thin film solar cell absorbers. Among them $Cu(In,Ga)Se_2$ (CIGSe) based thin film solar cells have been studied for several decades and resulted in power conversion efficiency (PCE) of 22.9% [1]. Another semiconductor material which responds to the requests of using only low-cost, non-toxic and earth-abundant elements is the kesterite $Cu_2ZnSn(S,Se)_4$. The PCE of the kesterite-based devices has stagnated at a level lower than 13% [2-4] in the last few years, which is much lower than the predicted value from the Shockley-Queisser limit. This difference between CIGSe and kesterite-based solar cell devices has also motivated research on the other quaternary copper chalcogenide compounds with suitable band gap energy for solar cell